OMI GDPS Algorithm to correct for wavelength shifts due to inhomogeneous slit illumination

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1 Referenced Documents

RD1 Wavelength Calibration Issues: Stability along the orbit worse than expected, TN-OMI-KNMI-XXX, R. Voors

RD2 GDPS Detailed Processing Model and Parameter Data List, SD-OMIE-7100-DS-251, Issue 6, 8 Nov 04.

2 Introduction

As a result of rapidly changing radiances along the orbit, the entrance slit of the OMI spectrograph is not always homogeneously illuminated. This results in wavelength shifts that are currently not corrected for by the GDPS. As a consequence the wavelength assignment for Measurement Class EARTH gives incorrect results. For a more detailed introduction to the problem, see RD1.

Studies indicate that the intensity variations of the small pixel columns within a measurement, or Master Clock Period, can be used to correct for the effect. This correction is to be made at the end of the wavelength assignment algorithm (RD2, Section 5.5.9) and only for Measurement Class EARTH. We leave it to the DS software developers to decide whether this correction will be implemented in the current wavelength assignment algorithm or if a new calculation algorithm will be added for Measurement Class EARTH.

There are a few important aspects to consider for the implementation:

1. The correction only applies for Measurement Class EARTH.
2. The correction factor uses the values of the Small Pixel Columns (SPC) after the Exposure Time Division (so in units of e/s)
3. If the correction cannot be applied, because the variation in SPC signal cannot be determined, a flag shall be raised.
4. There is no correction for the wavelength assignment in the UV1 channel. The correction for the wavelength assignment in UV2 uses the SPC of the UV detector and the correction in VIS uses the SPC of the VIS detector.

3 Algorithm Description

This algorithm only applies for Measurement Class EARTH. In this section we describe the algorithm as a separate step in the processing flow. However, it can at also be applied at the end of Calculation of spectral calibration coefficients (RD2, section 5.5.9).

3.1 Definition of Variables

Variables	Descriptive Name	C	D	U	Range	Reference
SPC_k	Expected value of SPC for each channel	I	ui	dl		OPF
$b\_OPF_n(jj)_{k,m}$	Inhomogeneous slit illumination correction coefficient	I	df	$(nm/pixel)^n$		OPF
$SMP(j,N_{co\text{-}addition,k})_k$	Small Pixel Column Radiances	I	df	e/s		Exposure time division (5.4.10)
$N_{co\text{-}addition,k}$	Co-addition factor	I	ui	dl	1,…,64	Datapreparation (5.2.1)
$c_n(j)_{k,m}$	Wavelength polynomial coefficients for each row within each subchannel	I	df	$(nm/pixel)^n$		Calculation of Spectral calibration coefficients (5.5.9)

Table 1: Input variables. Note that the first three entries in this table are new.

Variables	Descriptive Name	C	D	U	Range
m	Sub-channel identifier	L	ui	dl	UV1,UV2,VIS
k	Channel identifier	L	ui	dl	UV, VIS
n	Polynomial counter	L	ui	dl	0..5

jj	Row number on CCD	L	ui	dl	0,…,576
j	Row number in image	L	ui	dl	0,…,576
i	Column number in image	L	ui	dl	0,…,813
$Q(j)_k$	Correction factor for each channel	L	df	dl	
$b_{tmp,n}(j)_{k,m}$	Wavelength polynomial coefficients for each row within each subchannel	L	df	$(nm/pixel)^n$	

Table 2: Internal variables

Variables	Descriptive Name	C	D	U	Range
$c_n^{NEW}(j)_{k,m}$	Wavelength polynomial coefficients for each row within each subchannel	O	df	$(m/pixel)^n$	
wavel_assign_flag$_k$(i,j)	Flag indicating whether the correction for inhomogeneous slit illumination could be performed	DP	ui	dl	

Table 3: Output variables. Note that the entries in this table are new.

3.2 Equations

Transform the wavelength polynomial coefficients from CCD based to image based.

$$b_{temp,n}(j)_{k,m} = \frac{\sum b\_OPF_n(jj)_{k,m}}{f_{binning}(j)}$$

Note that this is done in a similar way as Eqs. (1a)–(1c) in Section 5.5.9.3 in RD2.

Calculate the normalized signal variation in the small pixel columns

$$Q(j)_k = 2\frac{SMP(j,Last)_k - SMP(j,First)_k}{SMP(j,Last)_k + SMP(j,First)_k}$$

Here, j is the row index and *First* and *Last* refer to the images that are co-added, for that row, and k indicates the channel. Note that no sub-channel index is given for Q, since for the UV1 no small pixel column radiances are available. So, we only take into account the first and the last of the small pixel signals for a given measurement and a given row. These are the SPC signals still in units of [e/s].

Next, the binned values are used to update the c_n parameters:

$$c_n^{NEW}(j)_{k,m} = c_n(j)_{k,m} + b_{temp,n}(j)_{k,m} \cdot Q(j)_k \quad \text{for m=UV2 and m=VIS}$$

$$c_n^{NEW}(j)_{k,m} = c_n(j)_{k,m} \quad \text{for m=UV1}$$

3.3 Exception handling and flagging

1. In case the number of co-additions is smaller than 2, then a correction cannot be made, and a flag shall be raised for that sub-channel.
2. If a small pixel is flagged, or the signal consists of fill values, then a flag shall be raised for the image row of the sub-channel.
3. If the SPC location on a CCD does not correspond to the expected value taken from the OPF, a flag shall be raised for that sub-channel.

In all cases above we have $c_n^{NEW}(j)_{k,m} = c_n(j)_{k,m}$ without the correction applied but with a flag being raised. This new flag shall be carried into (spare) bit 13 of the PixelQualityFlags. This bit shall be refered to as the 'Wavelength Assignment Warning flag. The description of this flag is as follows:
Flag indicating that the wavelength assignment includes the correction for wavelength shifts due to inhomogeneous scenes.
0 = Correction has been applied
1= Correction could not be applied

3.4 New OPF entries

The input parameter $b\_OPF_n(jj)_{k,m}$ constitutes a new entry in the Operational Parameter File with cardinality {577,5}. I.e. the number of rows (unbinned) is 577 and the number of wavelength polynomial coefficients is 5.

The input parameter SPC_k constitutes a new entry in the Operational Parameter File with cardinality {1}. It represents the expected values of the (column) location of the Small Pixel Columns on the detectors.